

Changes in Use and Consumption of Public Drinking Water During Pregnancy

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Background

- Disinfection by-products (DBPs) have been associated with various reproductive and developmental outcomes (e.g. low birth weight, stillbirths), mostly based on indirect exposure assessment methods (e.g., town average concentrations) which assume equal exposure levels for all subjects residing in one geographic area
- Intra- and inter-subject variability in water use activities can dramatically impact individual exposure levels and result in exposure misclassification bias in epidemiological studies
- Expectant mothers may modify behavior during pregnancy which can influence exposure characterization based on water use activities

Objectives

- Through a cooperative agreement, an international collaborative effort with scientists from the U.S. Environmental Protection Agency (U.S. EPA) and universities in the United States and the United Kingdom was established to refine exposure assessment methods for a prospective epidemiological study of spontaneous abortions and DBP exposure
- Changes in weekly average water intake, showering, and bathing patterns during early and mid-pregnancy were examined in relation to age, education, race, marital status, income, employment, and a healthy behavior index which integrated data on exercise, smoking, and intake of vitamins, alcohol, and recreational drugs.

Methods

- 1990 women were interviewed at ~9 and ~20 gestational weeks from 3 cities in the U.S.
- Eligibility criteria: ≥ 18 years of age; ≤ 12 weeks pregnant; no fertility treatment for the study pregnancy
- Pearson's correlation coefficients were calculated to measure the concordance between reported water use at early and mid-pregnancy
- Mixed regression models were used to partition the total variability in showering, bathing and water intake into intra-individual variability and inter-individual variability (i.e., between the different sampling periods)
- Linear regression models were used to identify predictors of changes in water use during pregnancy, adjusting for baseline levels and season in which questionnaire was administered

Results

- Average gestational age was 9 weeks at the initial interview (10th and 90th percentile = 6 and 12 weeks)
- Average gestational age was 20 weeks at the follow-up interview (10th and 90th percentile = 19 and 23 weeks)
- Average time between the two interviews was 11 weeks (10th and 90th percentile = 8 and 15 weeks)
- No change during pregnancy was reported for 62% and 63% of subjects for Hot Tap Water Intake and Bathing, respectively; among other subjects, similar proportions reported increasing and decreasing activity level (data not shown)
- Change in Showering time was not related to any demographic or behavioral variables (data not shown)
- Mean Cold Tap Water Intake was 1.7 L/day and 1.8 L/day during early and mid-pregnancy, while Total Water Intake was 2.4 L/day and 2.6 L/day, respectively; reported time spent Showering decreased by 14 minutes/week (Table 1)
- The proportion of total variation due to within-subject variability for early to mid-pregnancy changes was 42% for Total Water, 35% for Showering, 62% for Hot Tap Water, and ~50% for Bathing, Cold Tap Water, and Bottled Water Intake
- 96% of subjects changed their Total Tap Water Intake during pregnancy with 53% of subjects reporting increased intake; 45% of subjects increased Cold Tap Water Intake with 31% of subjects increasing by more than 0.5 L/day (Table 2)
- Reduced Showering time was reported by 37% of subjects, with 24% reporting increases and 40% reporting no change
- Moderate correlations between the two reporting periods were found for most variables, although reported time spent Bathing was highly correlated ($r=0.71$)
- Predictors of increased Cold Tap Water Intake during pregnancy included age >35 years, income $\leq \$40,000$, and non-Hispanic white ethnicity; Hispanic ethnicity was predictive of increased Bottled Water Intake >0.30 L/day (Table 3)
- Lower education, black non-Hispanic ethnicity, and a high healthy behavior score were associated with Bathing changes >20 min/week during pregnancy, while Showering was not associated with any of the variables that were examined

Table 1. Pearson's correlation coefficient (r), mean and 95% confidence interval (CI) of water use activities at initial interview (early pregnancy) and at the follow-up interview (mid-pregnancy), and variance partitioning into intra- and inter-variability.

	#	Mean (95% CI)	Pearson (r) (95% CI)	% of Total Variation due to Variation: * Within-subject	Between-subject
Water Intake (L/day)					
Cold Tap Water Intake**					
Early pregnancy		1.69 (1.63-1.76)			
Mid-pregnancy		1.84 (1.77-1.91)			
Early to Mid-pregnancy	1986		0.53 (0.49-0.57)	0.50	0.50
Hot Tap Water Intake**					
Early pregnancy		0.16 (0.14-0.17)			
Mid-pregnancy		0.16 (0.15-0.17)			
Early to Mid-pregnancy	1987		0.37 (0.33-0.41)	0.62	0.38
Bottled Water Intake					
Early pregnancy		0.57 (0.53-0.61)			
Mid-pregnancy		0.59 (0.55-0.65)			
Early to Mid-pregnancy	1983		0.56 (0.52-0.59)	0.46	0.54
Total Ingested Water					
Early pregnancy		2.43 (2.37-2.50)			
Mid-pregnancy		2.60 (2.53-2.67)			
Early to Mid-pregnancy	1968		0.40 (0.36-0.44)	0.42	0.58
Time Spent Showering/Bathing (min/wk)					
Showering					
Early pregnancy		119 (114-124)			
Mid-pregnancy		105 (101-110)			
Early to Mid-pregnancy	1984		0.57 (0.53-0.62)	0.35	0.65
Bathing					
Early pregnancy		48 (42-53)			
Mid-pregnancy		46 (41-52)			
Early to Mid-pregnancy	1762		0.71 (0.67-0.74)	0.47	0.53

*Mixed regression models were used to partition variance by fitting a random intercept model for each of the water variables.

**Information on filtered water intake was only available for the early pregnancy time point; therefore, ingested tap water includes intake of unfiltered and filtered tap water.

Results (continued)

Table 2. Frequency and proportion of subjects who increased, decreased, or made no changes in water use activities between early and mid-pregnancy.

Change	No change		Increasing		Decreasing	
	#	% of total	#	% of total	#	% of total
Cold Tap Water Intake (L/day)*						
< 0.5	388	19.6	275	13.9	236	11.9
0.5-1.0			233	11.8	187	9.4
1.0-1.5			134	6.8	109	5.5
1.5-2.5			146	7.4	111	5.6
≥ 2.5			92	4.6	70	3.5
Total			880	44.5	713	35.9
Bottled Water Intake (L/day)						
< 0.1	721	36.5	174	8.8	340	17.2
0.1-0.2			40	2.0	59	3.0
0.2-1.1			164	8.3	152	7.7
1.1-2.1			102	5.2	106	5.4
≥ 2.1			69	3.5	50	2.5
Total			549	27.8	707	35.8
Total Ingested Water (L/day)*						
< 0.4	76	3.9	233	11.8	206	10.5
0.4-0.9			216	11.0	203	10.3
0.9-1.6			320	16.3	247	12.6
1.6-2.5			160	8.1	108	5.5
≥ 2.5			110	5.6	89	4.4
Total			1039	52.8	853	42.3
Showering (min/week)						
< 25	770	39.9	117	5.9	158	8.0
25-35			22	1.1	45	2.3
35-70			175	8.8	247	12.5
70-140			106	5.4	170	8.6
≥ 140			49	2.5	119	6.0
Total			469	23.7	739	37.4

*Information on filtered water intake was only available for the early pregnancy time point; therefore, ingested tap water includes intake of unfiltered and filtered tap water.

Table 3. Mean change and p-value between early and mid-pregnancy for cold and hot tap water, bottled water, and bathing in relation to behavioral and socio-demographic variables.

	# (%)	Cold Tap (l/day)	Hot Tap (l/day)	Bottled (l/day)	Bathing (min/wk)
		Mean change* (p-value)	Mean change* (p-value)	Mean change* (p-value)	Mean change* (p-value)
Intercept		1.18	0.14	0.23	-7.8
Age at Last Menstrual Period (years)					
≤ 25	711 (36%)	ref.	ref.	ref.	ref.
26-30	646 (32%)	0.01 (0.95)	0.02 (0.37)	0.01 (0.89)	4.7 (0.44)
31-35	487 (24%)	0.04 (0.69)	0.04 (0.04)	0.01 (0.86)	5.9 (0.40)
≥ 36	146 (7%)	0.39 (<0.01)	0.05 (0.10)	-0.07 (0.40)	-0.7 (0.94)
Education					
≤ High school	549 (28%)	-0.11 (0.28)	0.03 (0.11)	0.09 (0.16)	24.5 (<0.01)
Some college	440 (22%)	-0.07 (0.42)	0.02 (0.41)	0.07 (0.24)	12.3 (0.06)
≥ 4 year college	1000 (50%)	ref.	ref.	ref.	ref.
Race/Ethnicity					
White, non Hispanic	1155 (58%)	ref.	ref.	ref.	ref.
Black, non Hispanic	582 (30%)	-0.34 (<0.01)	-0.12 (<0.01)	0.09 (0.09)	25.3 (<0.01)
Hispanic, any race	177 (9%)	-0.38 (<0.01)	-0.08 (<0.01)	0.34 (<0.01)	-16.1 (0.06)
Other	74 (4%)	-0.47 (<0.01)	-0.05 (0.12)	0.04 (0.68)	3.5 (0.76)
Marital Status					
Married	1358 (68%)	ref.	ref.	ref.	ref.
Single, never married	574 (29%)	0.09 (0.34)	-0.03 (0.20)	0.03 (0.57)	13.0 (0.05)
Other	57 (3%)	-0.28 (0.14)	-0.08 (0.05)	0.38 (<0.01)	28.1 (0.04)
Annual Income (\$)					
≤ 40,000	800 (42%)	ref.	ref.	ref.	ref.
40,001-80,000	662 (35%)	-0.23 (0.01)	-0.03 (0.15)	-0.06 (0.28)	12.3 (0.05)
> 80,000	449 (23%)	-0.30 (0.01)	-0.04 (0.09)	-0.05 (0.47)	7.9 (0.32)
Employment					
Yes	1398 (70%)	ref.	ref.	ref.	ref.
No	591 (30%)	0.00 (0.99)	0.02 (0.25)	-0.11 (0.02)	4.8 (0.33)
Health Index**					
≤ 3 points	169 (8%)	-0.08 (0.29)	-0.04 (0.01)	0.04 (0.46)	-1.8 (0.74)
4-5 points	1372 (69%)	ref.	ref.	ref.	ref.
6 points	448 (23%)	-0.01 (0.94)	0.06 (<0.01)	-0.05 (0.59)	19.7 (0.02)

*Multivariate linear regression models adjusted for season and level of intake/use during early pregnancy.

**One Point assigned for each of the following: ≤ 150 mg caffeine per day, vitamin use, no smoking, no alcohol, recreational exercise, no use of illicit drugs.

Discussion

- We found considerable differences in reported water use during two different periods of pregnancy; these changes were associated with various socio-demographic and behavioral variables and should be accounted for to minimize confounding in epidemiological studies of waterborne contaminants
- These data also highlight the importance of collecting detailed individual-level information at multiple times during pregnancy to better characterize exposures that can vary over time and minimize the potential for misclassification bias in epidemiological studies
- Future research should determine the degree to which changes in water use activities during pregnancy reflect true behavioral changes or whether they result from reporting/measurement error

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